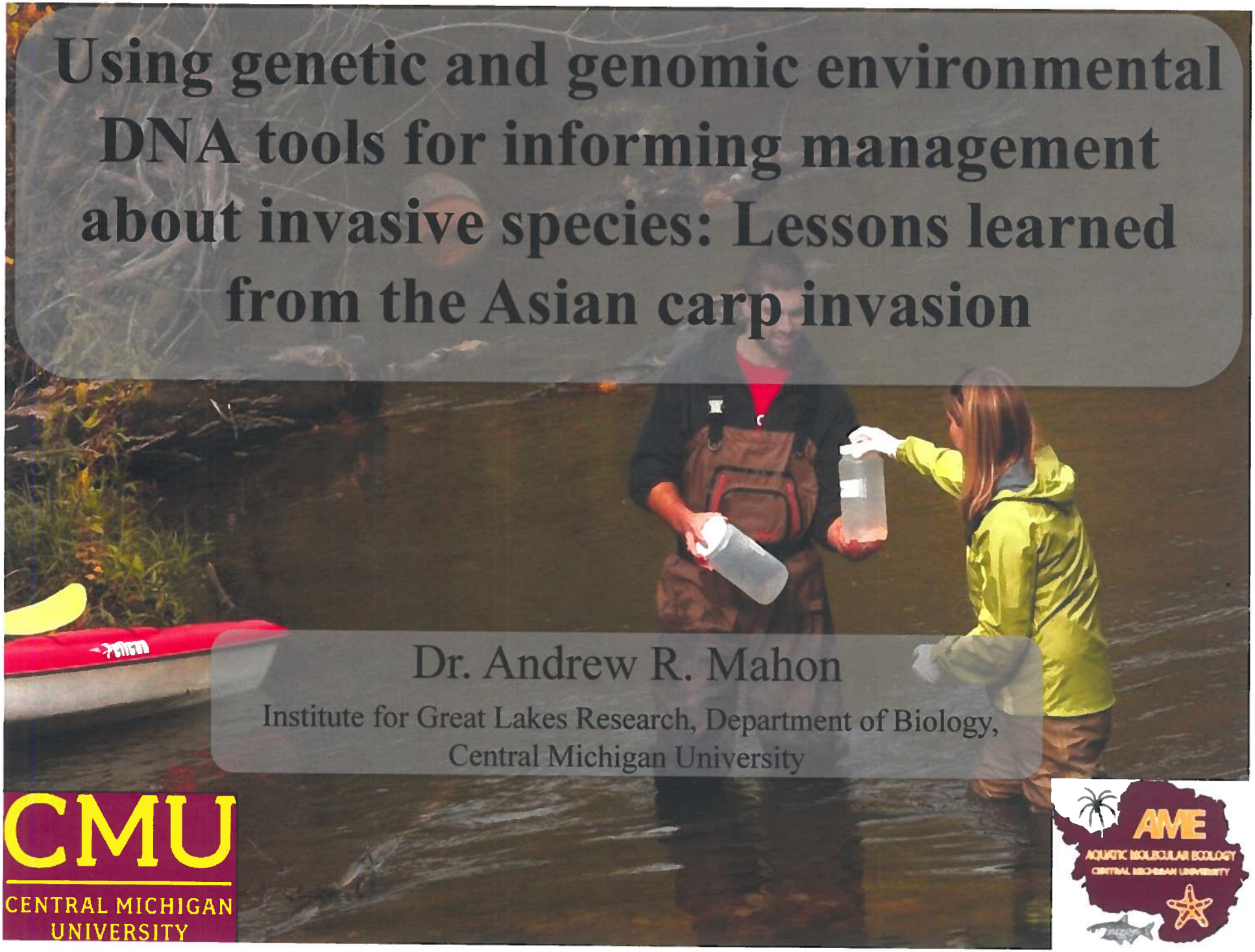
Using genetic and genomic environmental DNA tools for informing management about invasive species: Lessons learned from the Asian carp invasion

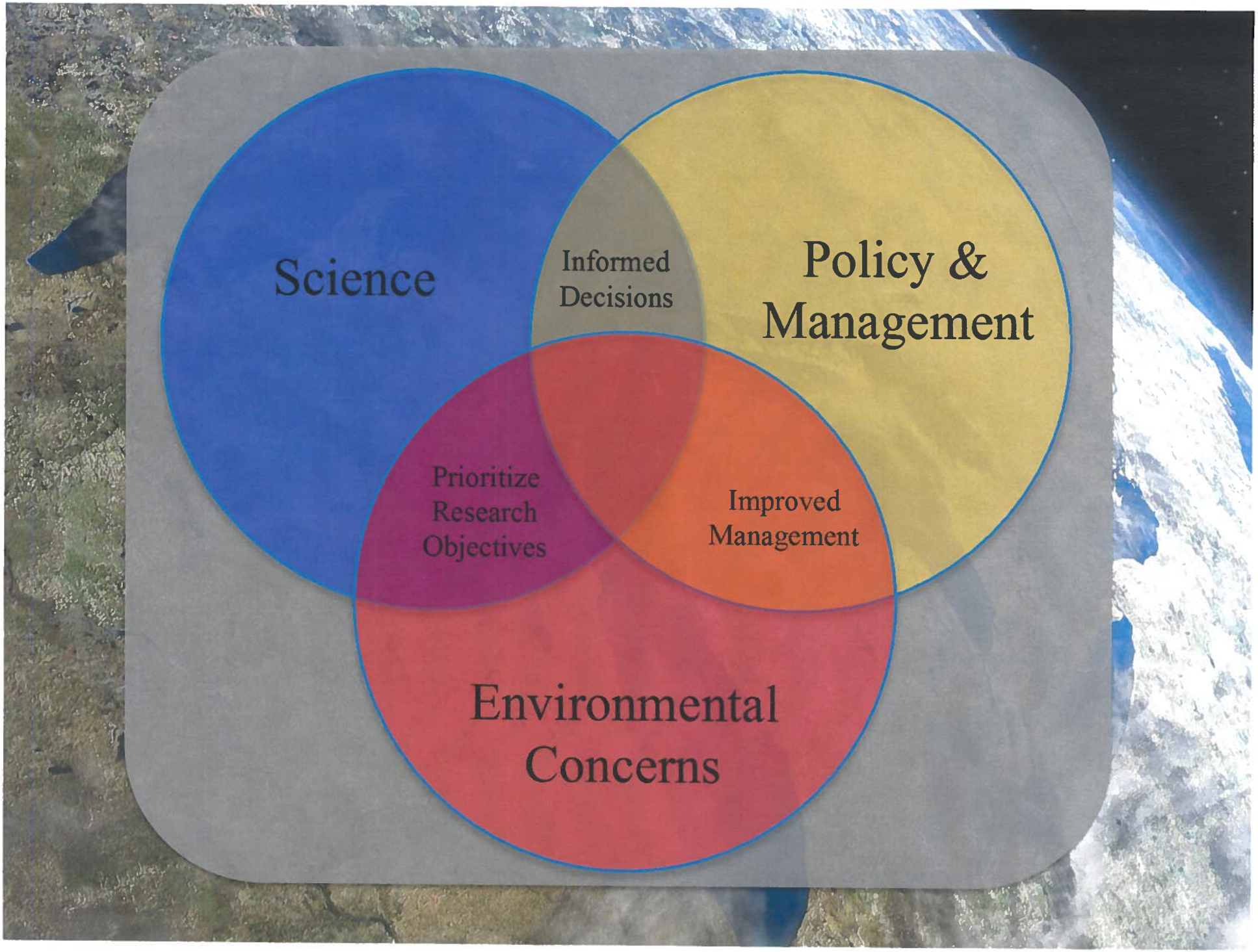


Dr. Andrew R. Mahon

Institute for Great Lakes Research, Department of Biology,
Central Michigan University

CMU
CENTRAL MICHIGAN UNIVERSITY

AME
AQUATIC MOLECULAR ECOLOGY
CENTRAL MICHIGAN UNIVERSITY


Science
Informed Decisions
Policy & Management
Prioritize Research Objectives
Improved Management
Environmental Concerns

Can we detect species at low abundance?

When faced with rare or elusive species, there are two alternatives to improving detection:

1. Increase effort

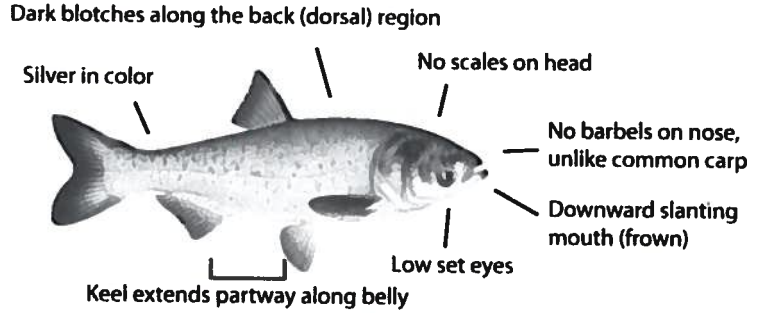
2. Change to more sensitive methods of detection

L.L. McDonald (2004) In *Sampling Rare or Elusive Species*

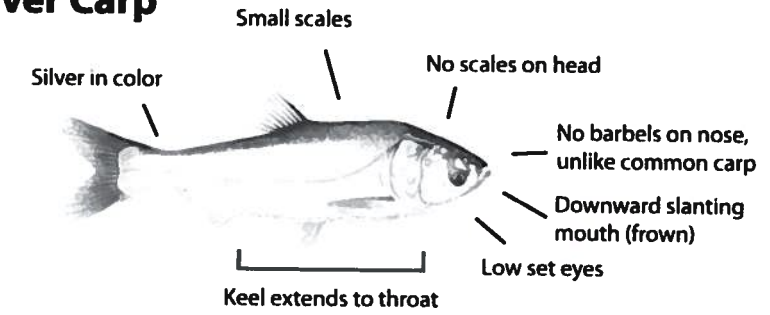
Not elusive! Direct Direct Indirect

Asian carp

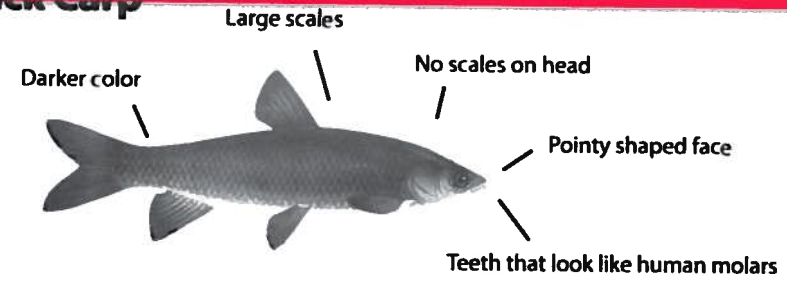
Bighead Carp

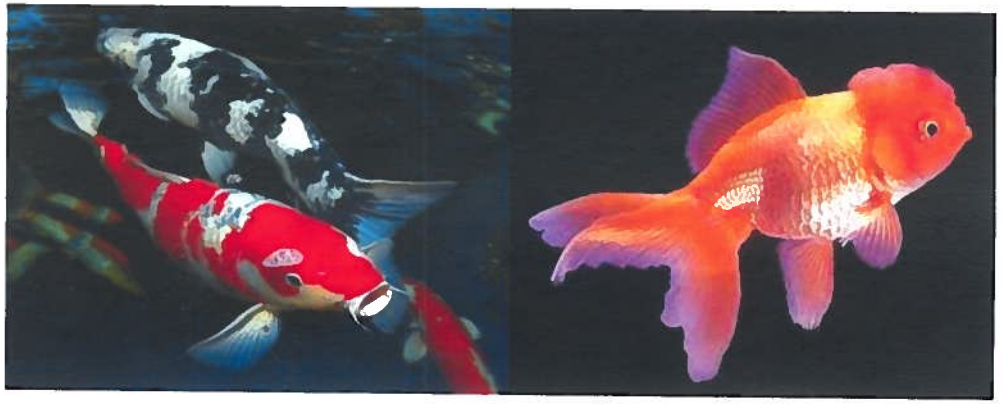


Silver Carp



Black Carp





The Asian carp invasion front: Spring 2009

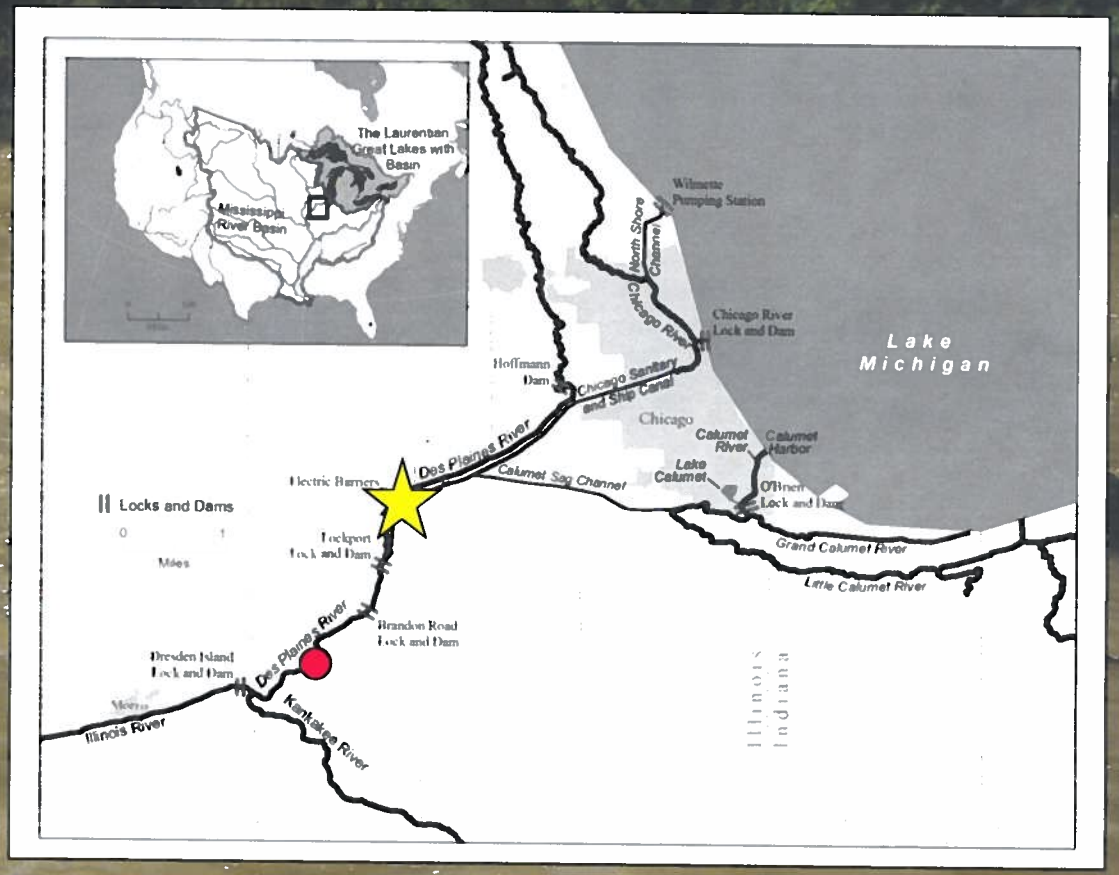
Bighead and silver carp captured in Dresden Island Pool

Population densities drop dramatically moving north

Nothing closer than 65 river miles from Lake Michigan

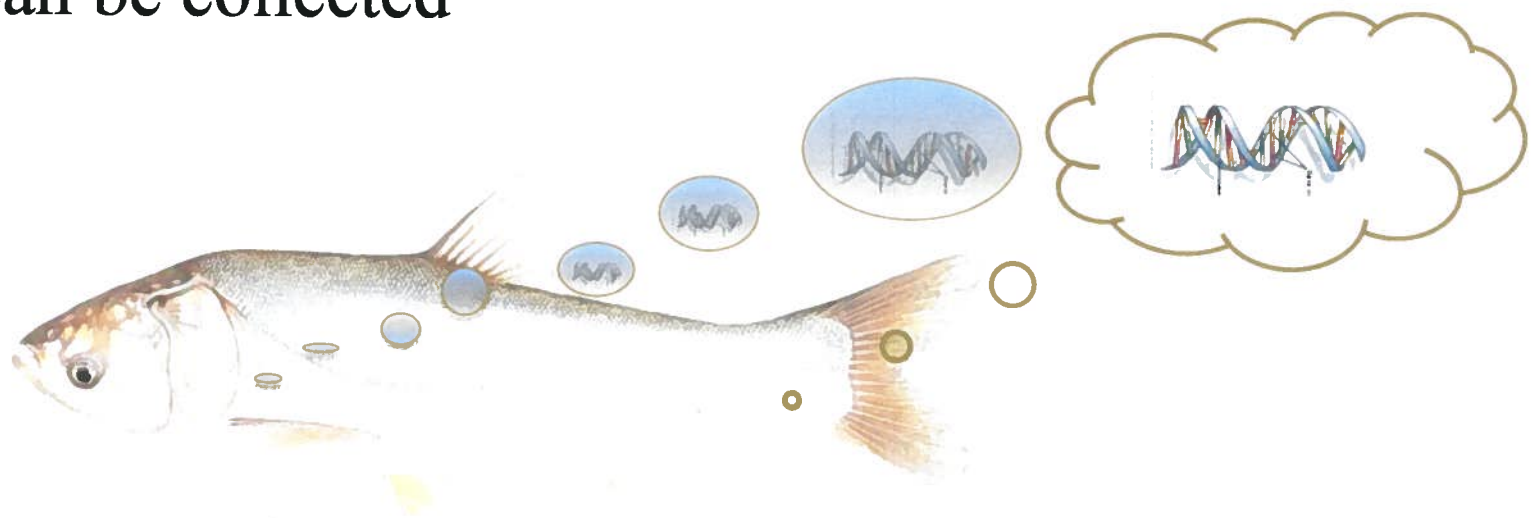
15 miles from the electric barrier

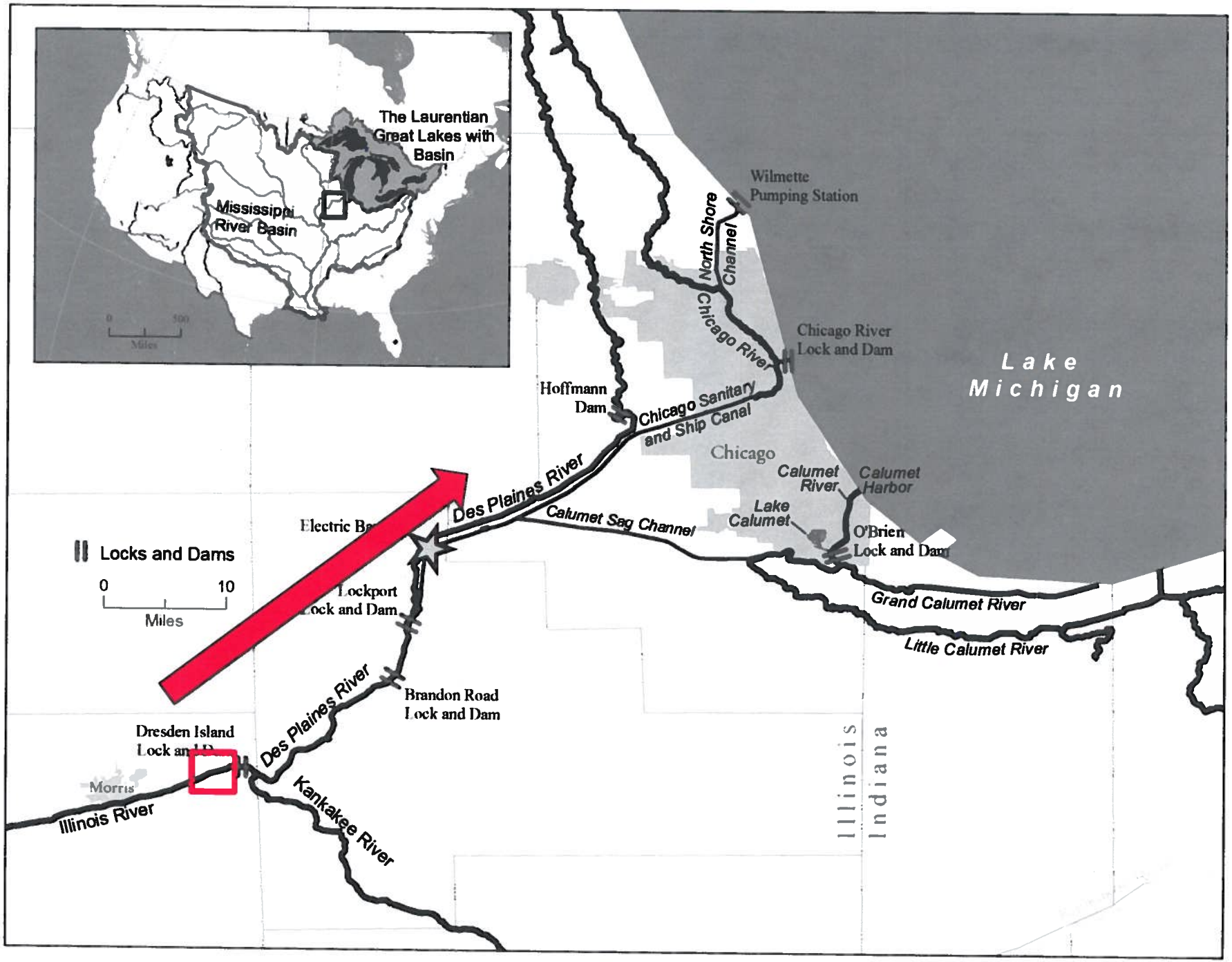
Few individuals = stalled invasion



Better technology for detection?

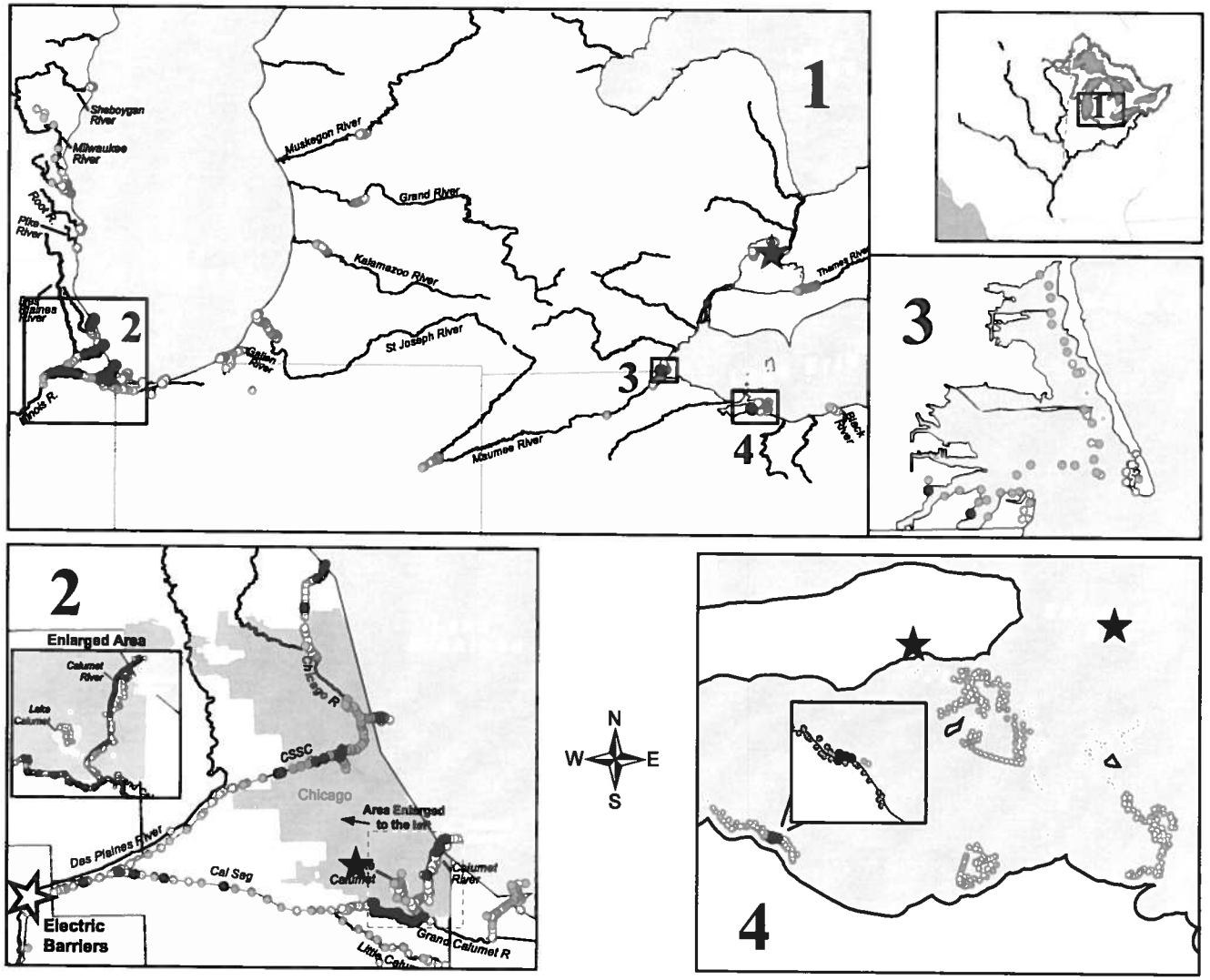
- All organisms naturally shed DNA in sloughed cells, mucus, epithelial cells in feces and urine, etc. into the environment
- These materials are carried in suspension in water and can be collected




The Laurentian Great Lakes with Basin
Mississippi River Basin
Wilmette Pumping Station
North Shore Channel
Chicago River
Chicago River Lock and Dam
Lake Michigan
Hoffmann Dam
Chicago Sanitary and Ship Canal
Chicago
Calumet River
Calumet Harbor
Lake Calumet
O'Brien Lock and Dam
Des Plaines River
Calumet Sag Channel
Electric Ba
Locks and Dams
0
10
Miles
Lockport Lock and Dam
Grand Calumet River
Little Calumet River
Brandon Road Lock and Dam
Dresden Island Lock an
Des Plaines River
Morris
Illinois River
Kankakee River
Illinois
Indiana

2009-2011:

2822 samples collected and screened for bighead and silver carp



Jerde, Chadderton, **Mahon**, Renshaw, Corush, Budny, Mysorekar, Lodge. 2013. Detection of Asian carp DNA as part of a Great Lakes basin-wide surveillance program. *CJFAS*.

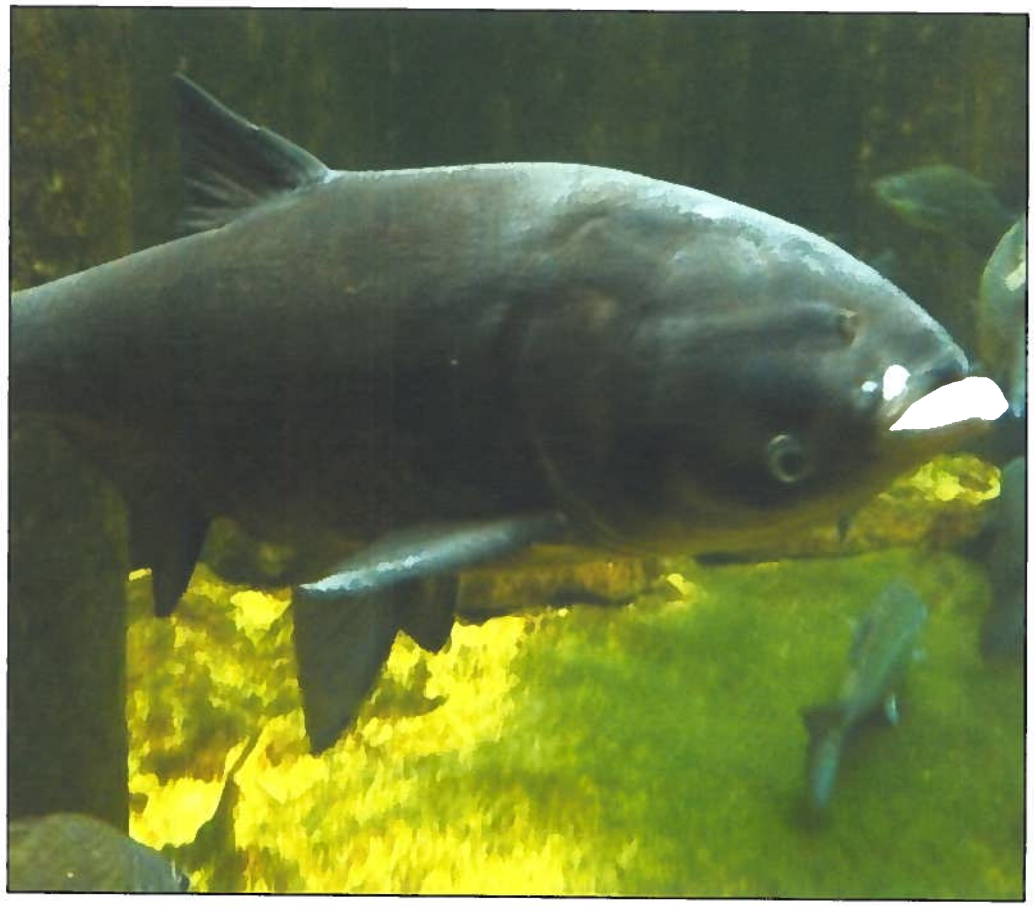
Conservation Letters 2011

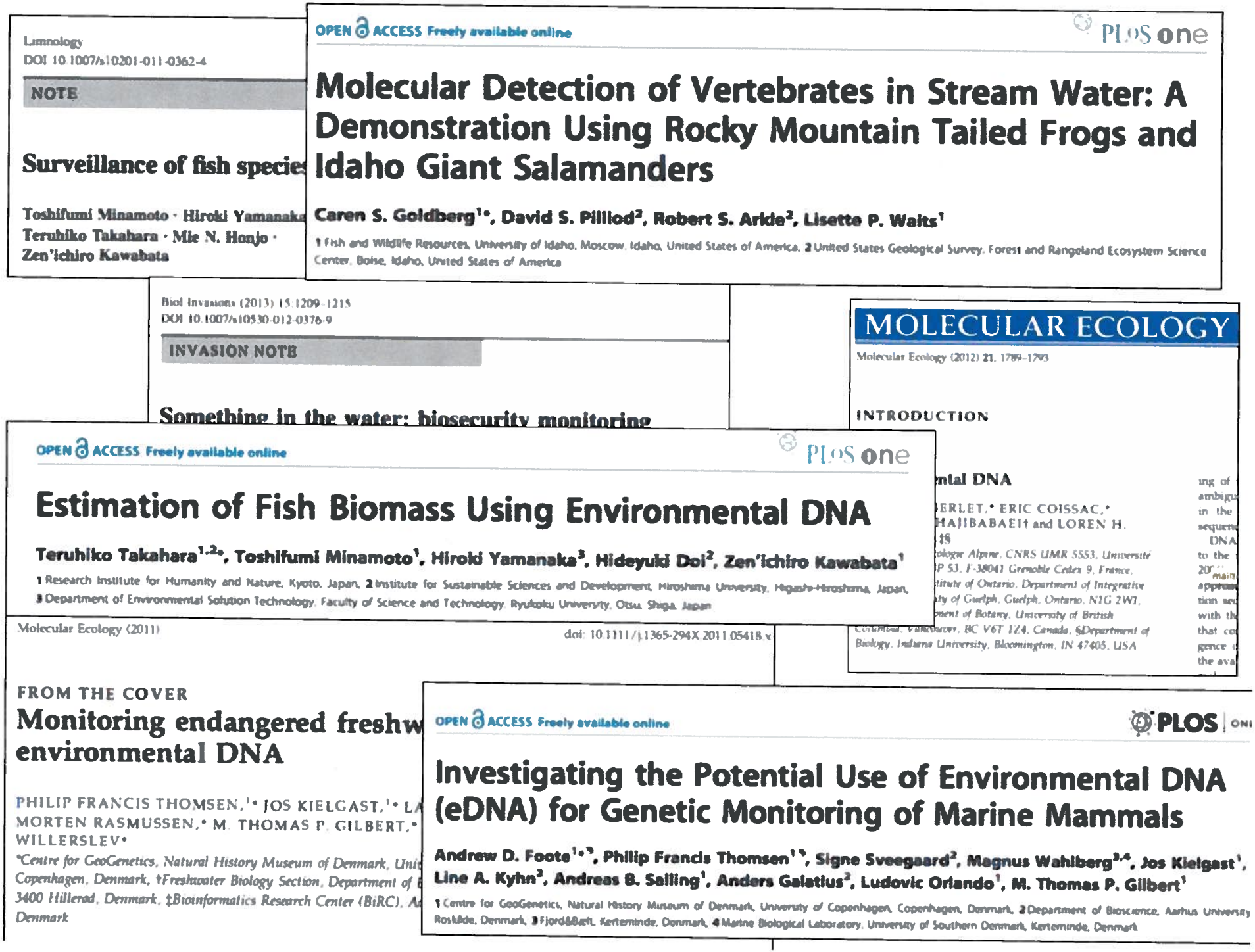
LETTER

"Sight-unseen" detection of rare aquatic species using environmental DNA

Christopher L. Jerde[1], Andrew R. Mahon[1], W. Lindsay Chadderton[2], & David M. Lodge[1]

[1] Center for Aquatic Conservation, Department of Biological Sciences, University of Notre Dame
[2] Great Lakes Project, The Nature Conservancy





Limnology
DOI 10.1007/s10201-011-0362-4

NOTE

Surveillance of fish species

Toshifumi Minamoto · Hiroki Yamanaka · Teruhiko Takahara · Mie N. Honjo · Zen'ichiro Kawabata

OPEN ACCESS Freely available online

PLoS one

Molecular Detection of Vertebrates in Stream Water: A Demonstration Using Rocky Mountain Tailed Frogs and Idaho Giant Salamanders

Caren S. Goldberg[1]*, David S. Pilliod[2], Robert S. Arkle[2], Lisette P. Waits[1]

1 Fish and Wildlife Resources, University of Idaho, Moscow, Idaho, United States of America, 2 United States Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, Idaho, United States of America

Biol Invasions (2013) 15:1209–1215
DOI 10.1007/s10530-012-0376-9

INVASION NOTE

Something in the water: biosecurity monitoring

MOLECULAR ECOLOGY

Molecular Ecology (2012) 21, 1789–1793

INTRODUCTION

ntal DNA

ERLET,* ERIC COISSAC,* HAJIBABAEI† and LOREN H. ‡§

ologie Alpine, CNRS UMR 5553, Université P 53, F-38041 Grenoble Cedex 9, France, titute of Ontario, Department of Integrative ty of Guelph, Guelph, Ontario, N1G 2W1, nent of Botany, University of British Columbia, Vancouver, BC V6T 1Z4, Canada, §Department of Biology, Indiana University, Bloomington, IN 47405, USA

ing of ambigu in the sequen DNA to the 20 main appro tion se with th that co gence the ava

OPEN ACCESS Freely available online

PLoS one

Estimation of Fish Biomass Using Environmental DNA

Teruhiko Takahara[1,2]*, Toshifumi Minamoto[1], Hiroki Yamanaka[3], Hideyuki Doi[2], Zen'ichiro Kawabata[1]

1 Research Institute for Humanity and Nature, Kyoto, Japan, 2 Institute for Sustainable Sciences and Development, Hiroshima University, Higashi-Hiroshima, Japan, 3 Department of Environmental Solution Technology, Faculty of Science and Technology, Ryukoku University, Otsu, Shiga, Japan

Molecular Ecology (2011)

doi: 10.1111/j.1365-294X.2011.05418.x

FROM THE COVER

Monitoring endangered freshw environmental DNA

PHILIP FRANCIS THOMSEN,[1]* JOS KIELGAST,[1]* LA MORTEN RASMUSSEN,* M. THOMAS P. GILBERT,* WILLERSLEV*

*Centre for GeoGenetics, Natural History Museum of Denmark, Unit Copenhagen, Denmark, †Freshwater Biology Section, Department of 3400 Hillerød, Denmark, ‡Bioinformatics Research Center (BiRC), A Denmark

OPEN ACCESS Freely available online

PLOS ONE

Investigating the Potential Use of Environmental DNA (eDNA) for Genetic Monitoring of Marine Mammals

Andrew D. Foote[1]*[☯], Philip Francis Thomsen[1☯], Signe Sveegaard[2], Magnus Wahlberg[3,4], Jos Kielgast[1], Line A. Kyhn[2], Andreas B. Søling[1], Anders Galatius[2], Ludovic Orlando[1], M. Thomas P. Gilbert[1]

1 Centre for GeoGenetics, Natural History Museum of Denmark, University of Copenhagen, Copenhagen, Denmark, 2 Department of Bioscience, Aarhus University, Roskilde, Denmark, 3 Fjord&Bælt, Kerteminde, Denmark, 4 Marine Biological Laboratory, University of Southern Denmark, Kerteminde, Denmark

Initial findings from eDNA studies

- Environmental DNA technologies are rapid, accurate tools for surveillance in aquatic systems.

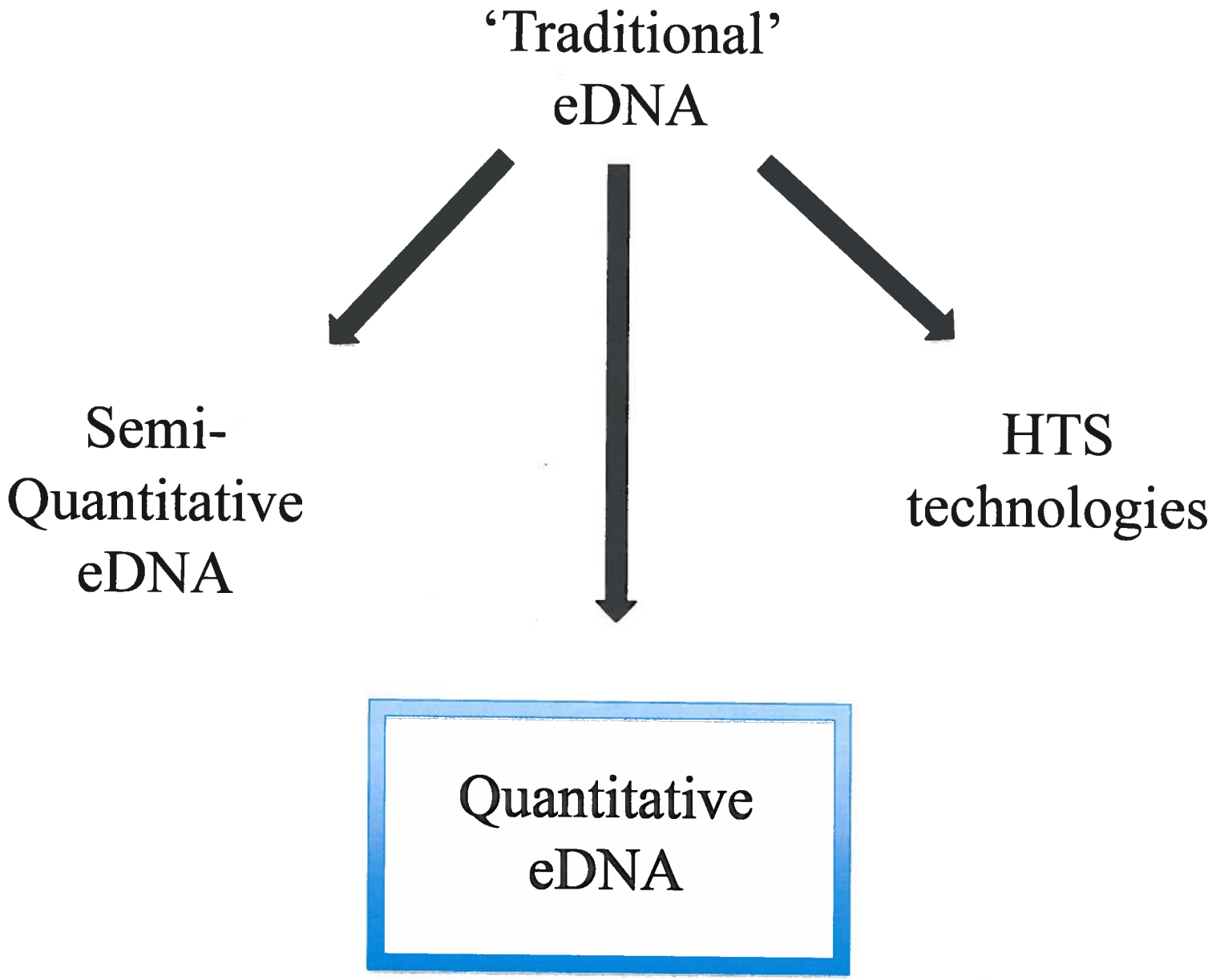
- EPA-GLRI projects: Any given sample can be screened with 14+ markers for AIS of interest
  - Not just for bighead and silver carp anymore…

- Questions remain…

Recurring questions….

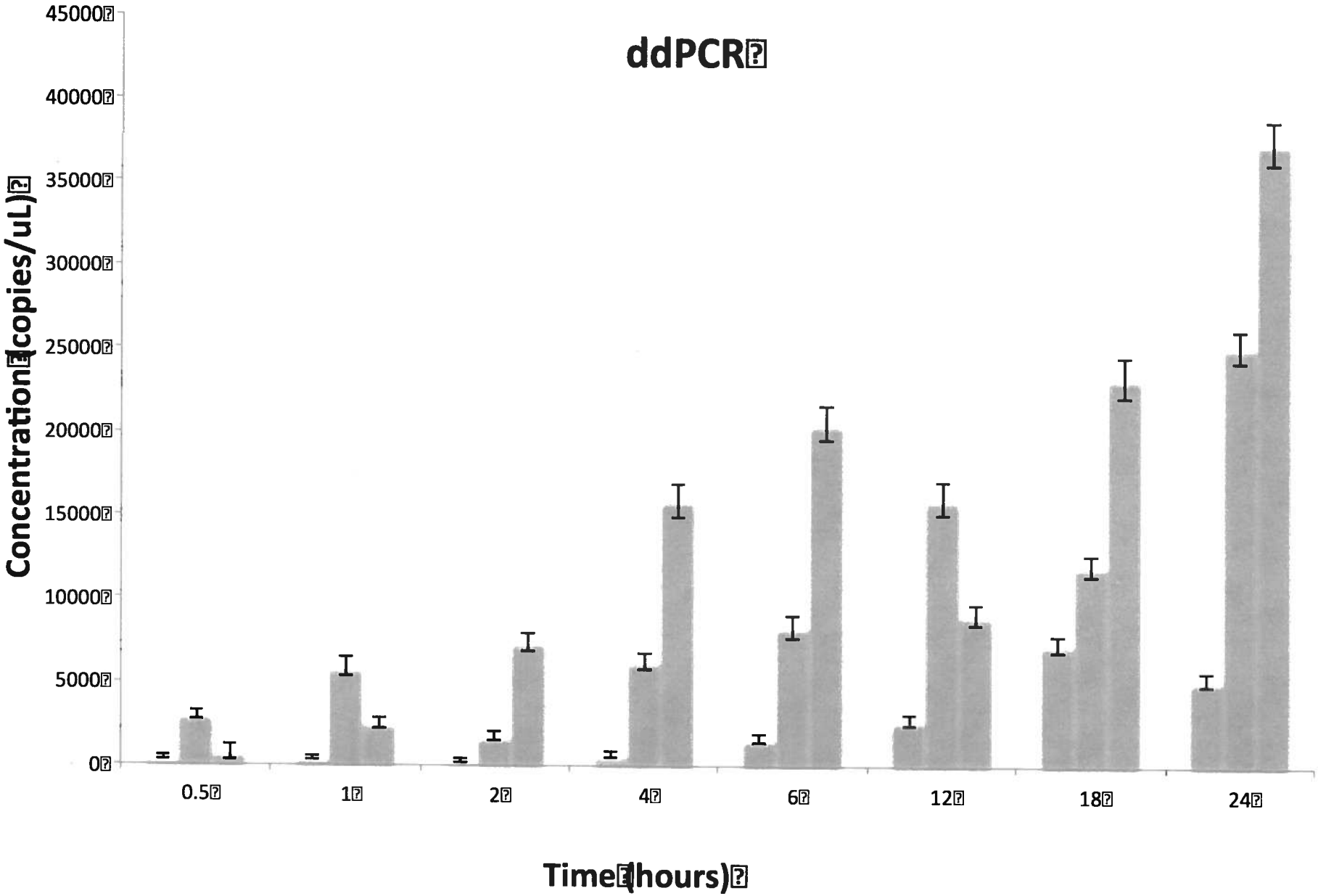
- How many fish are out there?

- Can we move from qualitative analyses to more quantitative measures?

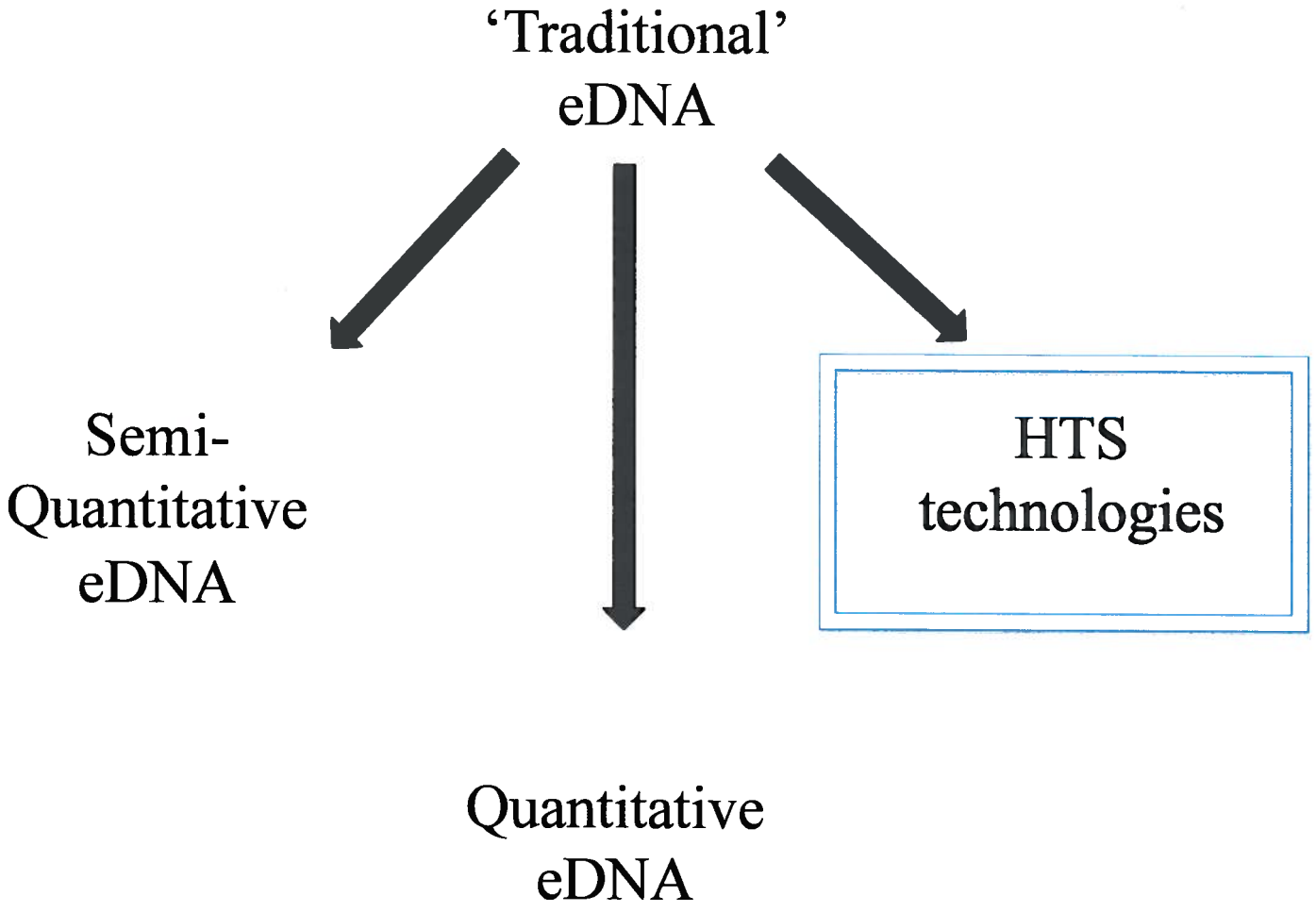

'Traditional' eDNA
Semi-Quantitative eDNA
HTS technologies
Quantitative eDNA

Quantitative eDNA: Digital Droplet PCR

- Physical count of target molecules
  - Greater sensitivity, particularly at lower concentrations
  - More rapid and accurate measure of target species DNA
  - Cheaper per sample!


ddPCR
Concentration (copies/uL)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0.5
1
2
4
6
12
18
24
Time (hours)

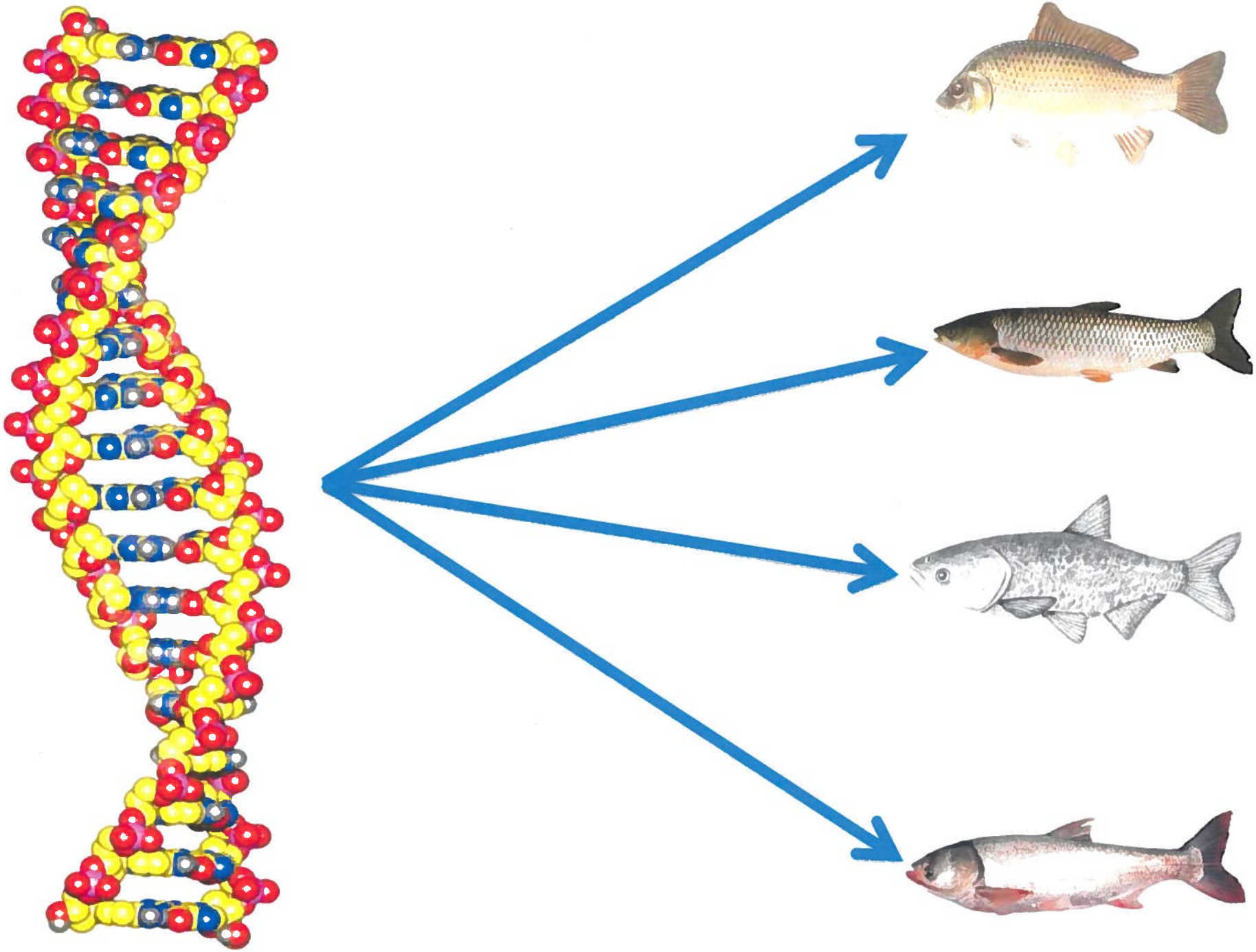
Even newer methods for eDNA surveillance

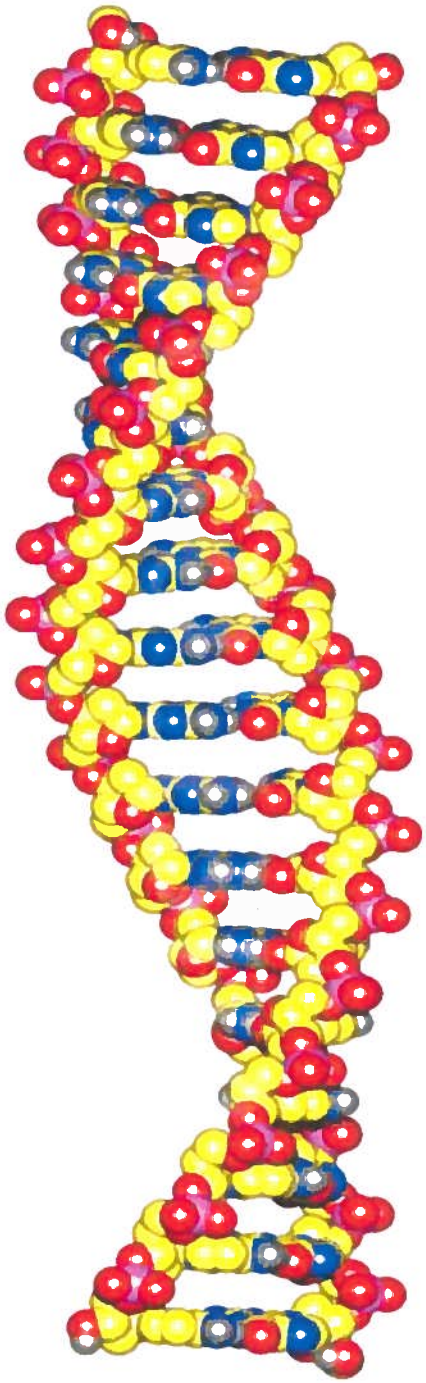


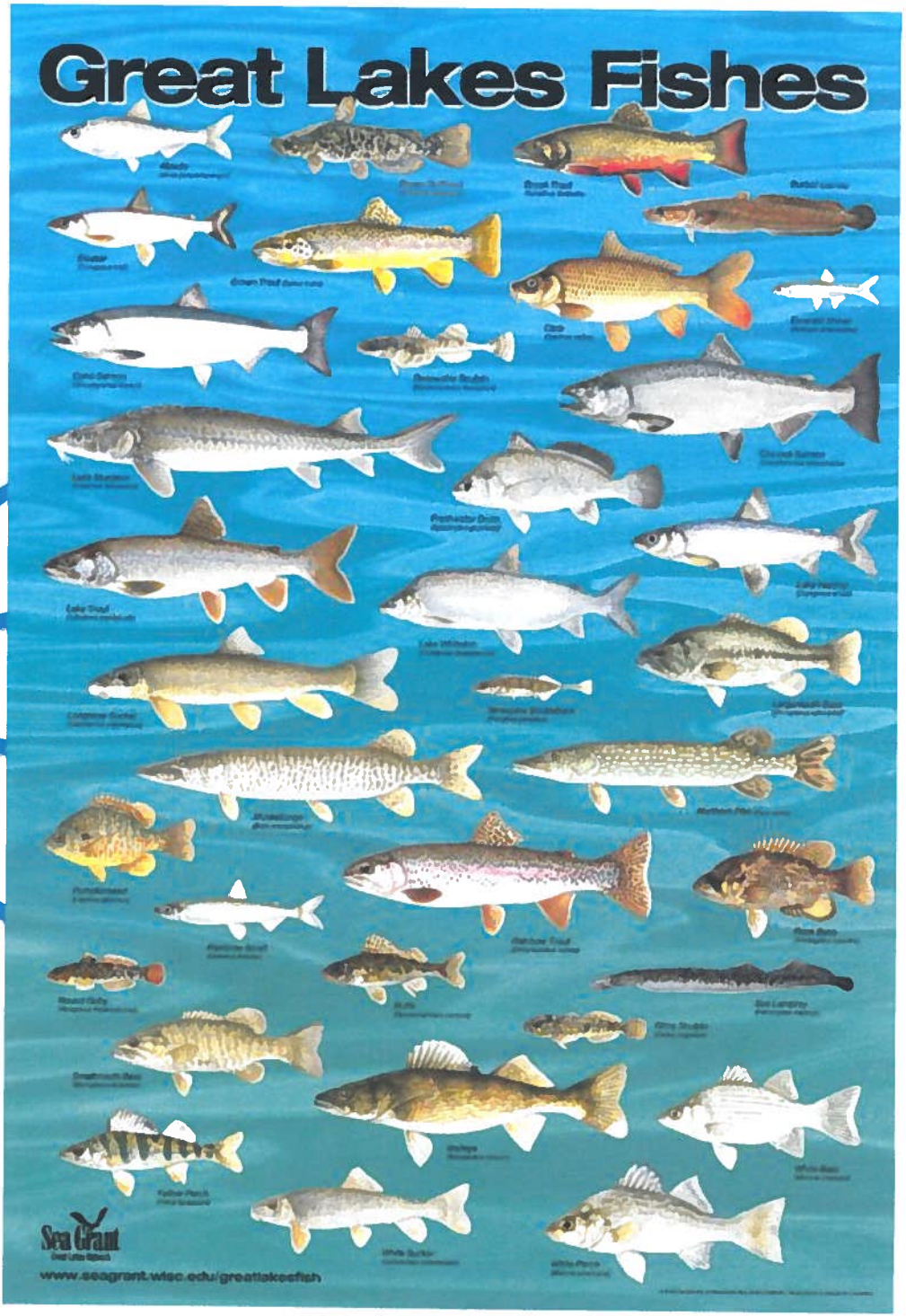
The future…

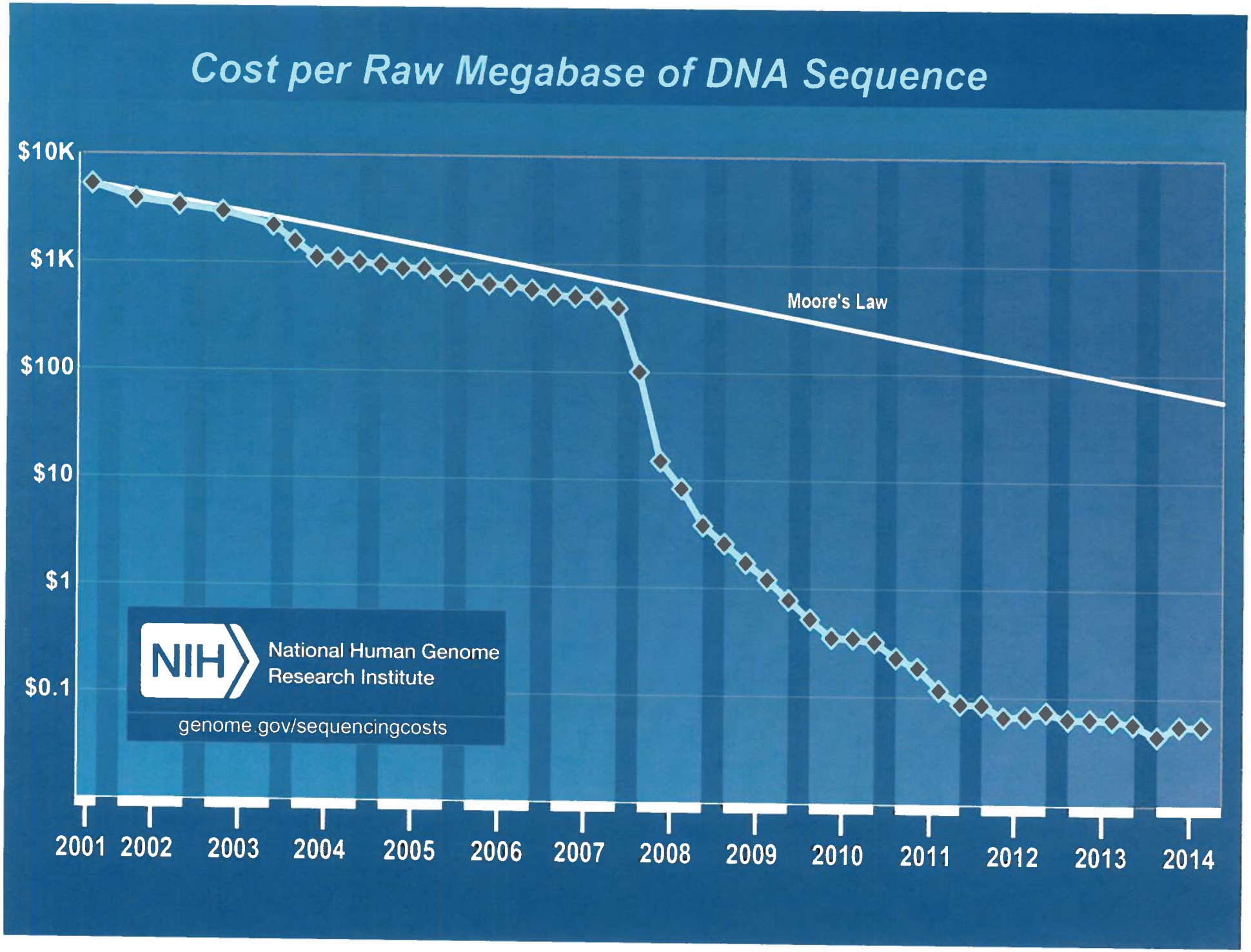
- High throughput (a.k.a. next generation) sequencing technologies

  – Instead of targeting individual species in a sample, why not sequence EVERYTHING to obtain total biodiversity and potentially estimate abundance?






Great Lakes Fishes
Sea Grant
www.seagrant.wisc.edu/greatlakesfish


Cost per Raw Megabase of DNA Sequence
$10K
$1K
$100
$10
$1
$0.1
Moore's Law
NIH
National Human Genome Research Institute
genome.gov/sequencingcosts
2001
2002
2003
2004
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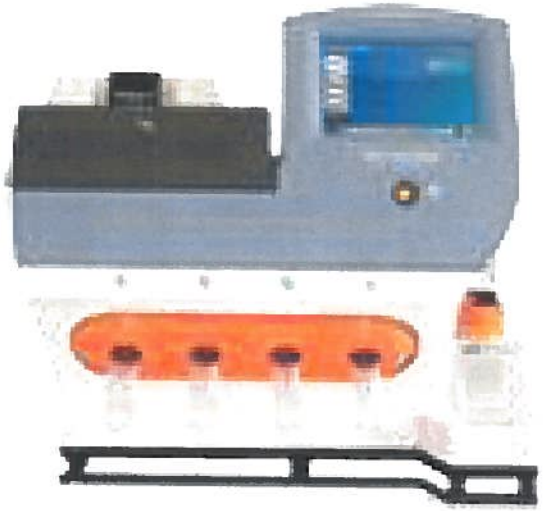
2011
2012
2013
2014

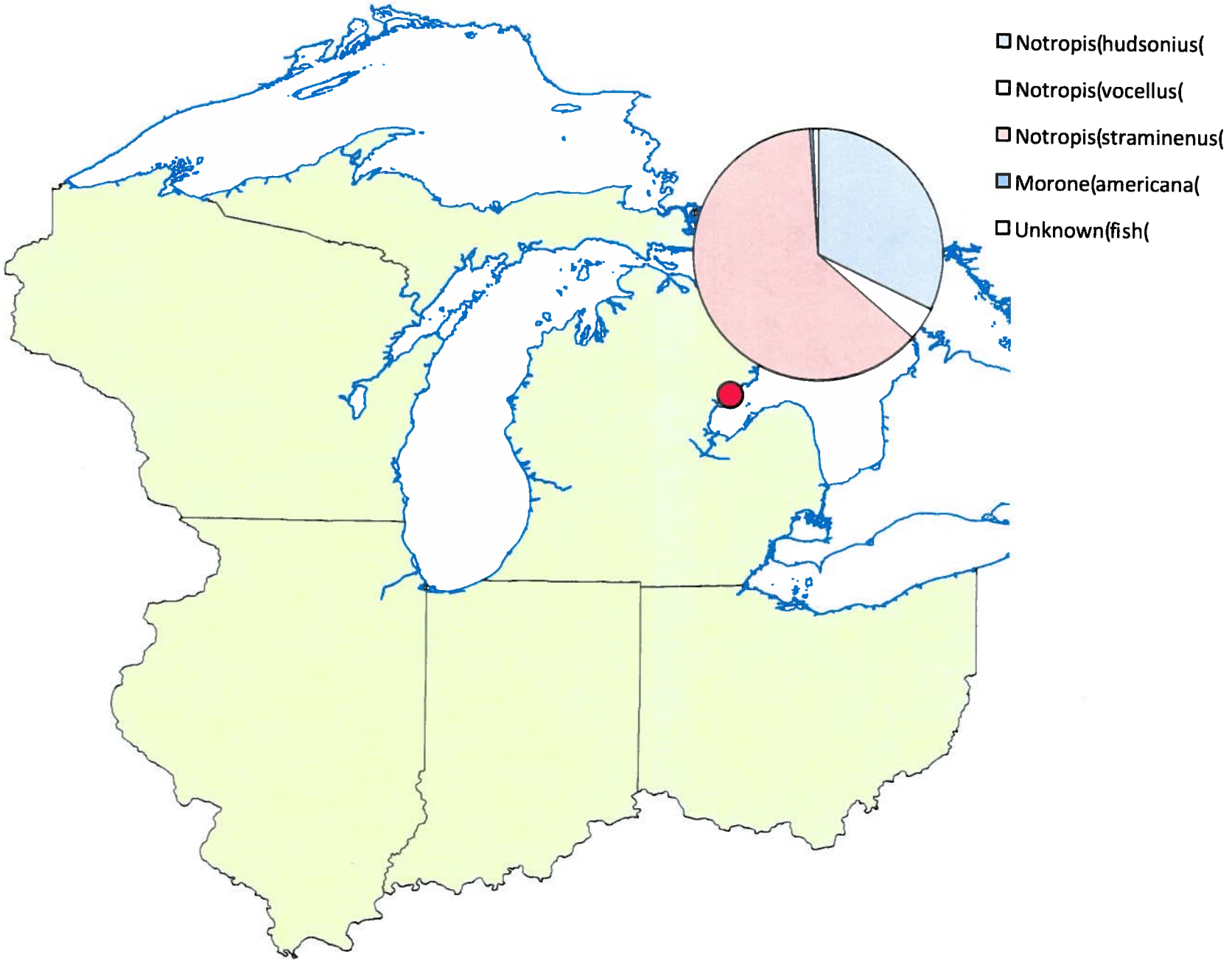
illumina



ion torrent

Roche


MinION

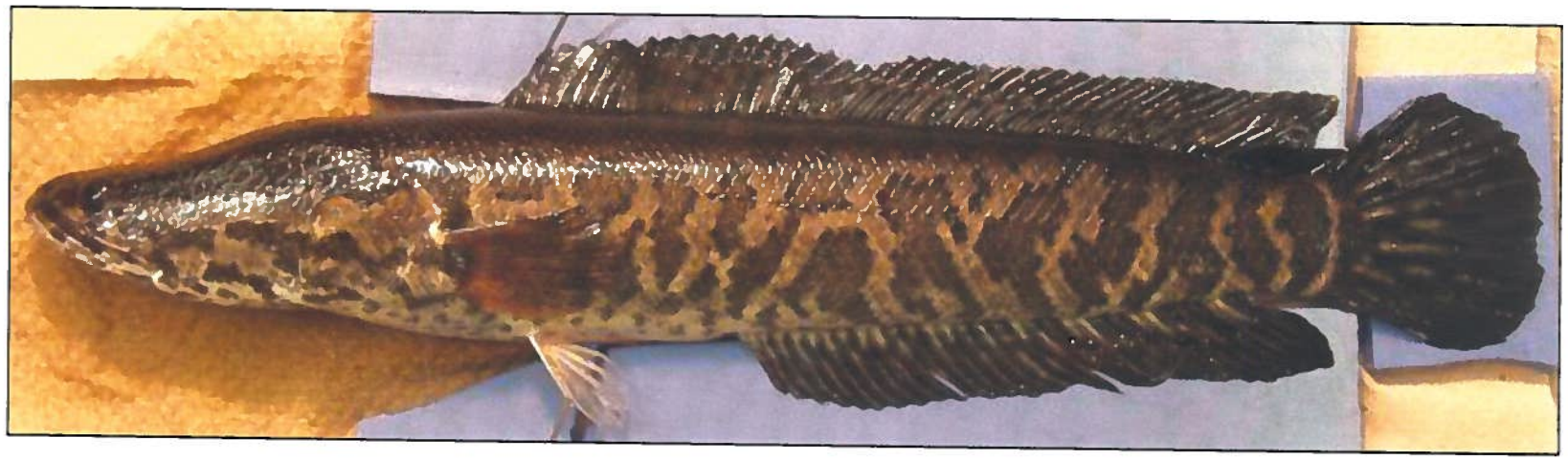

Notropis(hudsonius(
Notropis(vocellus(
Notropis(straminenus(
Morone(americana(
Unknown(fish(

Conclusions

- Asian carp are moving into the Great Lakes basin.
- Genetic/genomic surveillance is a valuable monitoring tool
  - Rare species in the environment
- New technologies constantly advancing

Final thought….

- Be proactive, rather than reactive with regards to invasive species. Use EVERY tool in the toolbox to help.



Great Lakes RESTORATION

- Chris Jerde, Lindsay Chadderton
- USFWS (GLRI), USEPA-GLRI and additional GLRI contracts through IL-DNR and-IN DNR